proportionally to their radii, the declivity is most where the length of curve is least. Now it would appear that the velocity of the stream must increase where the inclination is greatest, but the momentum of the flowing water reverses the action at those bends. A stream of water running from a straight channel into a curvilinear one, from the impetuosity of its motion, is carried onward and strikes the concave side, from which it is reflected to the opposite bank, at an angle approaching to the angle of incidence—for it cannot be equal to it, on account of the inelasticity and friction of the soil, and the viscidity of the particles of the water—from whence it is again reflected to the opposite bank, leaving the intermediate parts of the banks much less acted upon; and thus a series of convexities and concavities are formed along the channel. Therefore, a great portion of the momentum of the stream is expended along the concavities, from the progress of the water having somewhat of an angular motion, although not strictly so.

It has been deduced directly from observations and experiments, that a running stream of water moves with the greatest velocity at or near the upper surface in the middle of the stream, and that the velocity gradually diminishes from thence to the bottom and sides of the channel where it is the least; and the mechanical action of the water is always strongest where the depth and velocity are greatest; for in proportion as the depth and velocity decrease from the middle of the upper surface towards the bottom and sides, the mechanical action of the water upon the channel is also diminished in the same ratio. As the depth of the stream increases, the abrasion upon the channel must also increase in proportion to the pressure, but, although the abrasion increases with the pressure, it is somewhat proportionably less for larger pressures than for smaller ones. When pressure is removed and a body of water is allowed to flow, motion always takes place first in the middle of the stream, for according to the general law of gravitation, the mobility of the particles of the water when set in motion presses them against each other in endeavouring to obtain their lowest position; therefore, the filament in the middle is the first that seeks to escape, and the lateral filaments by losing their stability, slide or fall towards the centre of the channel; and when the stream is constant, they are continually endeavouring to supply the places of the middle ones. It is a well ascertained fact, that the channels of rivers and running brooks, assimilate very much to the concave curve of a circle transversely to the flow of the streams. When water collects into channels, it becomes a powerful mechanical agent in wearing away and carrying along the detrited soil, and both the widths and depths of all channels are dependent upon the nature of the substances of the ground and their degrees of induration, the banks sloping towards the channels at angles, which are peculiar to the nature of the soils; it is evident that the outline of the channel must be influenced by the peculiar quality and induracy of the soil, but it would appear that the *regime* of concavity is caused by the mechanical actions of the gradations of the velocity and pressure of the several filaments upon the channel, for the regular diminution of the velocities of the stream from the middle of the surface to the bottom and sides, and the proportional pressures of the water upon the base, produce a proportional diminution of abrading action upon the surface of the channel; thus, by the spontaneous operations of nature, the varying and proportional actions of the various velocities of the stream, and the proportional pressures of the water in contact with the bed, produce its curvilinear form.

In obedience to the natural law of the force of gravity when a stream of water is in motion down an inclined plane, every particle of the fluid endeavours to seek the lowest position to which it can attain, in order to find a state of repose. In pursuit of this object, every particle of the fluid from the farthest extremity of the stream at the sides towards the middle, in endeavouring to attain a central position, acts with a proportional increase of pressure against those next to it, and thus produces a maximum velocity in the middle of the stream. And in all cases the gravitating action of water by its exertion while descending to the lowest accessible level, and when collected into narrow circular channels, produces a power which becomes a most efficacious mechanical instrument in collecting and carrying along with it all the deposits and impediments it may come in contact with in its course, as well as the animal and vegetable refuse of towns. But in order to render the water available in lifting these excrementitious and other substances, and of sufficient power for promoting the necessary transmission of this refuse, a constant and copious supply is absolutely essential. As, in proportion to the quantity of water and the energetic impulse of the stream upon its channel, the removal of these substances is mainly dependent; and the mechanical power of the water, that raises these substances and carries them along in suspension, is more or less according to the depth and quantity, as well as the velocity with which it moves; and the augmentation of the latter is dependant in a great measure upon the declivity of the channel.

A considerable retardation of the velocity and power of a running stream, is produced by the resistance it receives from the friction of the surface of the channel, and the amount of friction is in proportion to the extension of the surface with which the water, while in motion, is in contact, as every point of the surface of the channel exerts a force directly opposed to the motion of the current. And it is this friction which imparts a resistance throughout the moving body, neutralizing the accelerating power of gravity and abrasion of the water, and making the stream to move with a uniform velocity along its various sections and declivities. It appears from the well-known law, of *extent of surface retarding the motion of water*, that if a stream of water be spread out, and allowed to run, in a rectangular channel, the amount of friction and consequent retardation will be much greater than if the same amount of water be confined to a circular channel, for the perimeter of the circle is less than that of any other figure of the same area, and conversely, the circle contains the greatest area of any polygonal or rectangular figure of the same perimeter, therefore, with a given sectional area of water, the amount of the abrading surface, or friction upon the bed, increases as the surface of contact increases, and will be determined by the form and perimeter of the channel through which it flows. Circular channels, therefore, are the most advantageous; where velocity and power of running water are required, as circles have less frictional and resisting surfaces under the same area; and it is for this reason that pipes are made circular for the quick conveyance and distribution of water, gas, smoke, sound, and many other contrivances in the arts. But the applicability and adaptation of these properties of the circle are the most essential in the formation of water channels, for the transmission of noxious animal and vegetable matter by the mechanical agency of suspension in running water, as for instance, house-drains, and public sewers. Now as a contracted circular channel meets the conditions of increased depth, velocity, and power of the stream, then unquestionably, according to the nature of the ground, a circular or elliptical form, with the longer axis upwards, is by far the best for offering the greatest resistance to external pressure with the same amount of materials, and for the quick transmission of any substances by the agency of running water; therefore, this form should in all cases be adopted for house drains, and public sewers; in fact, in a scientific point of view, that this is the best form, there cannot be the least doubt.

By observing the motions of running waters, it would appear that the particles do not move in straight and parallel lines, whatever may be the form and direction of the channel, for, in consequence of the resistance imparted to the current by the friction and asperities of the bed, the particles in contact and moving along the bottom are divided, diffused, and reflected in all directions, to distances that are proportional to the velocities of the stream; and the advancing and progressing force and momentum of gravitation of the waters turns and carries the reflected particles along in revolving and curvilinear motions: and it would appear that these conflicting motions by crossing, recrossing, and intermingling with one another, and with different velocities, retard the equal and uniform motion of the stream throughout its depth, and in consequence the velocity increases proportionally from the bottom to the upper surface, or, the velocity and action increases from the bed upwards as the resisting motions of the particles of the water reflected from the channel become expended and destroyed by the descending action of the force of gravity; for if the particles of water, from the momentum of the stream in moving along the channel, are reflected by the friction and asperities of the bed, may not each particle, however minute, be likened to any other projectile, and be subject to the same law of retardation and acceleration of gravity, and may not the diminution of velocity from the surface to the bottom and sides be thus accounted for?

In consequence of the winding courses of most tidal rivers, the channel which suits the current of the flux may be altogether different to that which suits the reflux, and the obliquity of the reflected streams of the former may not take place at the same points and fly off at the same angles as those of the latter; thus, an oscillatory and sideway motion of the soil on the bed will be produced, and the actions of the flood and ebb alternately cause shoals and ridges of sand and gravel to collect in the channel, and, in consequence of these obstructions, much of the power and velocity of the currents is checked and expended by breakers and eddies, and the water escapes and flows with an increased velocity between the channels formed by the shoals. In all tidal rivers the courses of the alternate currents, and those parts where their actions upon the channels are most strong, are peculiarly marked and observable when the ebb at spring tides is at the lowest. The winding course of rivers and rivulets lengthens and reduces the declivity of the channel, and the velocities are much less and the water higher in the elbows and bends; and where the currents move with the greatest rapidity the channels are most frequently the straightest. When a stream is constrained to move in the direction of a curve, its motion and course is constantly varying, because, from the centrifugal force of its motion, every concentric filament of the stream running round the curve evinces a tendency to fly off, or quit it at a tangent. The velocities of each concentric filament will be greater or less in proportion as their relative distances from the centre of the circle are greater or less, and the centrifugal force increases in proportion as the radius of curvature increases; therefore, the velocity of the stream augments as it recedes from the convex side. All angles and bends very much diminish the progression of the passing currents, and the retardation increases with the smallness of the curves and the abruptness of the angles.

The viscidity of the particles of the fluid and the friction of the channel conjointly, by their action, produce a uniformity in the motion of the water; and when all the obstructions, friction, and resistances of the channel, together, become equal to the force which accelerates the motion of the water, the stream will be uniform, having then no particular mechanical action on the bed, the velocity and abrading action of the stream and the sum of the resisting forces being mutual. When this takes place, and not till then, a permanency of the channel and a regimen of the river will be obtained. The disintegration of clayey and gravelly bottoms takes place by imperceptible degrees, the lesser particles of the soil being removed; then the larger ones, being left free and not held by other tenacious substances, the power of the water drives them along, and these in their progress lick away the soft and impalpable particles, and thus those bottoms not possessing resisting qualities become worn down by the superior mechanical action of the water. All soils have a certain stability consistent with the velocity of the water acting upon them; and by examining separately the effects produced by variations of the velocities of water upon soils, a knowledge of the actions of the running waters of rivers upon their beds is obtained. As different kinds of soil constitute the bottoms of rivers, a knowledge of the various velocities which act upon and carry along different-sized bodies, is of great importance in determining the nature of the soil for the bed, which shall maintain a certain breadth, depth, and velocity of a river. Now it has been ascertained from various experiments, that water flow-